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Upscale and forward transfer of kinetic energy: Impact on giant planetary jet and vortex formation

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In this study, we analyse the non-linear transfer of kinetic energy in simulations of convection in a 3D rotating shell. Our aim is to understand the role of upscale transfer of kinetic energy and a potential inverse cascade for the formation of zonal jets and large vortices on the giant planets Jupiter and Saturn. We find that the main driving of the jets is associated with upscale transfer directly from the convection scale to the jets. This transfer of energy is mediated by Reynolds stresses, i.e. statistical correlations of velocity components of the small-scale flow. Intermediate scales are mostly not involved, therefore strictly speaking the jets are not powered by an inverse energy cascade. To a much smaller degree, energy is transferred upscale from the convective scale to large vortices. However, these vortices also receive energy from the jets, likely due to an instability of the jet flow. Concerning transport in the forward direction, we find as expected that the 3D convective motions transfer energy to the even smaller dissipation scales in a forward cascade.